

REPORT

Strain Gages properties

Company: Micro-Measurement Division

Type: WK – 09 – 250BG – 350

W → fully encapsulation in glass-fiber-reinforced epoxy-phenolic resin

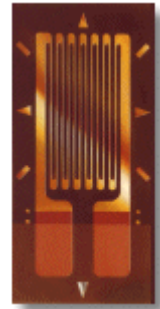
K → nickel-chromium alloy (for self-temperature-compensated gages)

09 → thermal expansion coefficient of the structural material

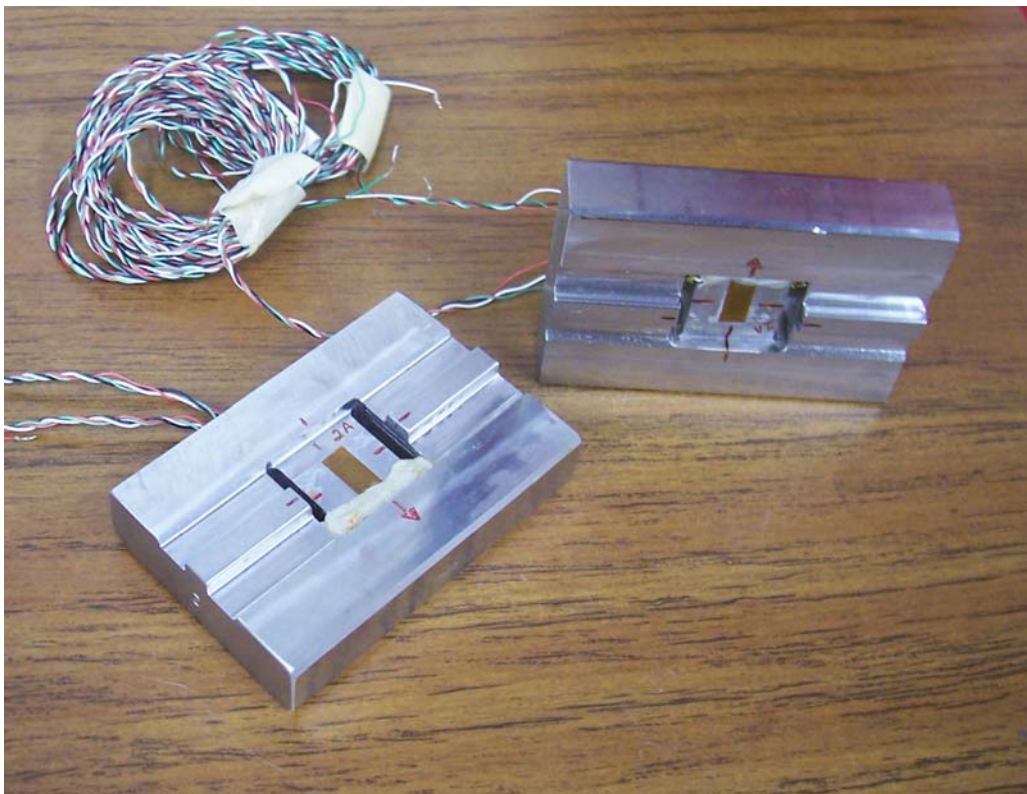
250 → active gage length

BG → grid and tab geometry

350 → nominal resistance



Warm Calibration results



Temperature: 300 K & 4.2K

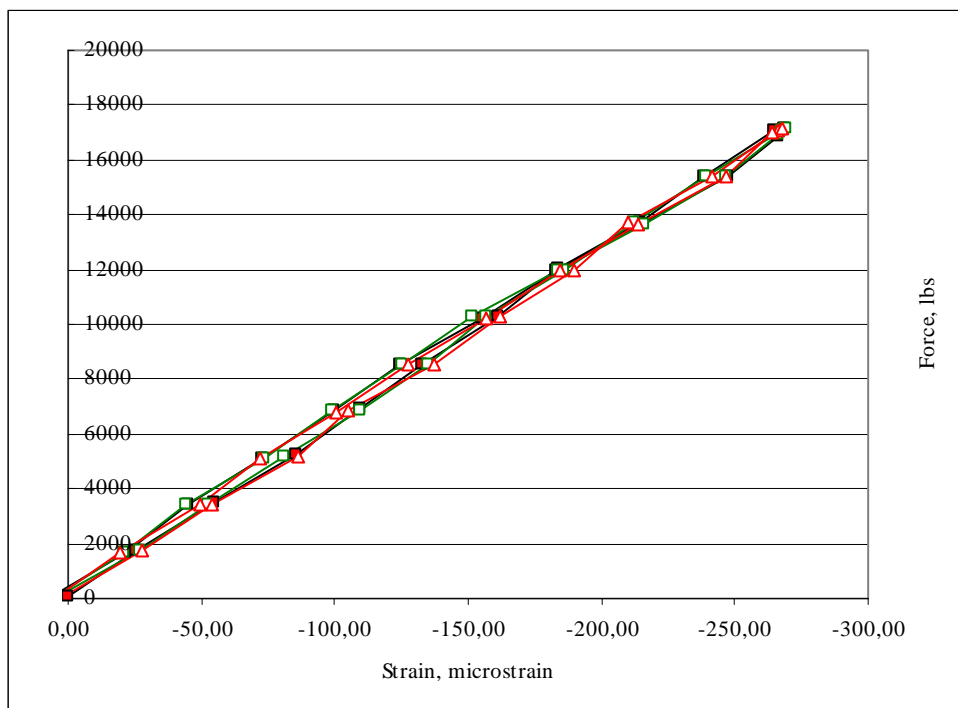
Number of blocks: 8

Runs: 3 (for each block)

We want to make a plot of Force function of strain...so we have to calculated points starting from data we know from calibration:

Known Parameters	Calculated Parameters
Area & Pression	Force
Back Resistance value (nominal & with deformation)	Resistance Variation 1
Front Resistance value (nominal & with deformation)	Resistance Variation 2
Resistance Variation 1 & Resistance Variation 2	Variation Average
Resistance (R_n), Variation Average (dR), Gage factor (G)	Strain ($dR=R_n \cdot G \cdot \text{Strain}$)
Front strain, Back strain	Strain Average

Typical plot (3 runs):

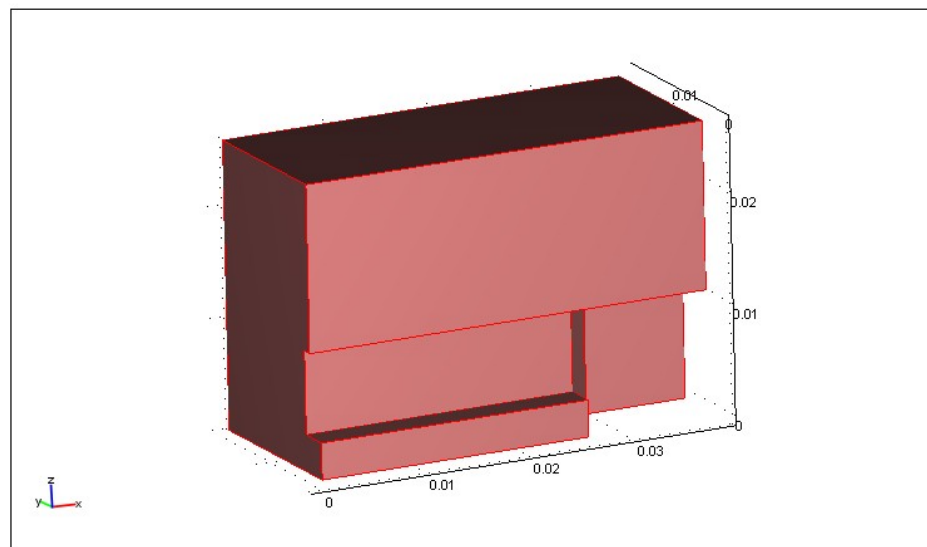
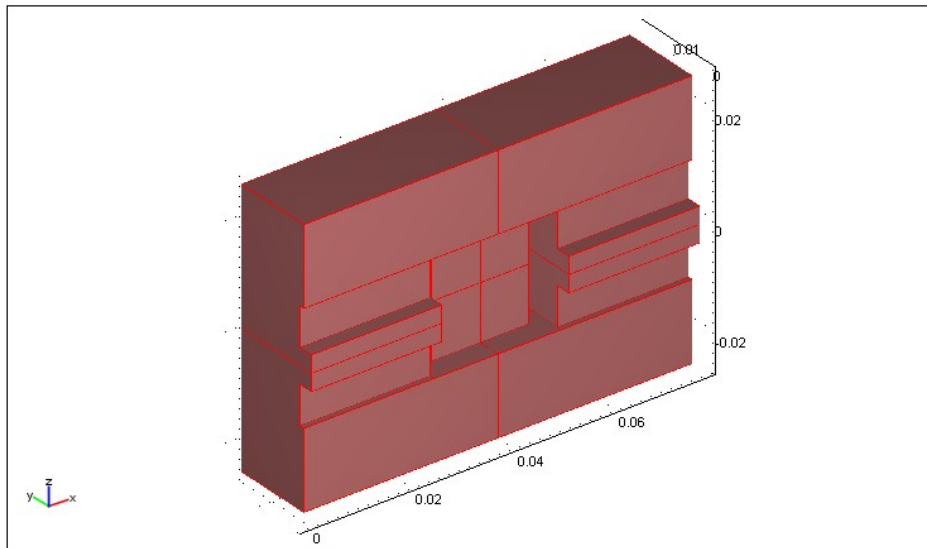


Force considered for comparison with simulations: 17130 lbs (max value applied)

Calculated Strain: 268 microstrains

Femlab's modeling and simulation

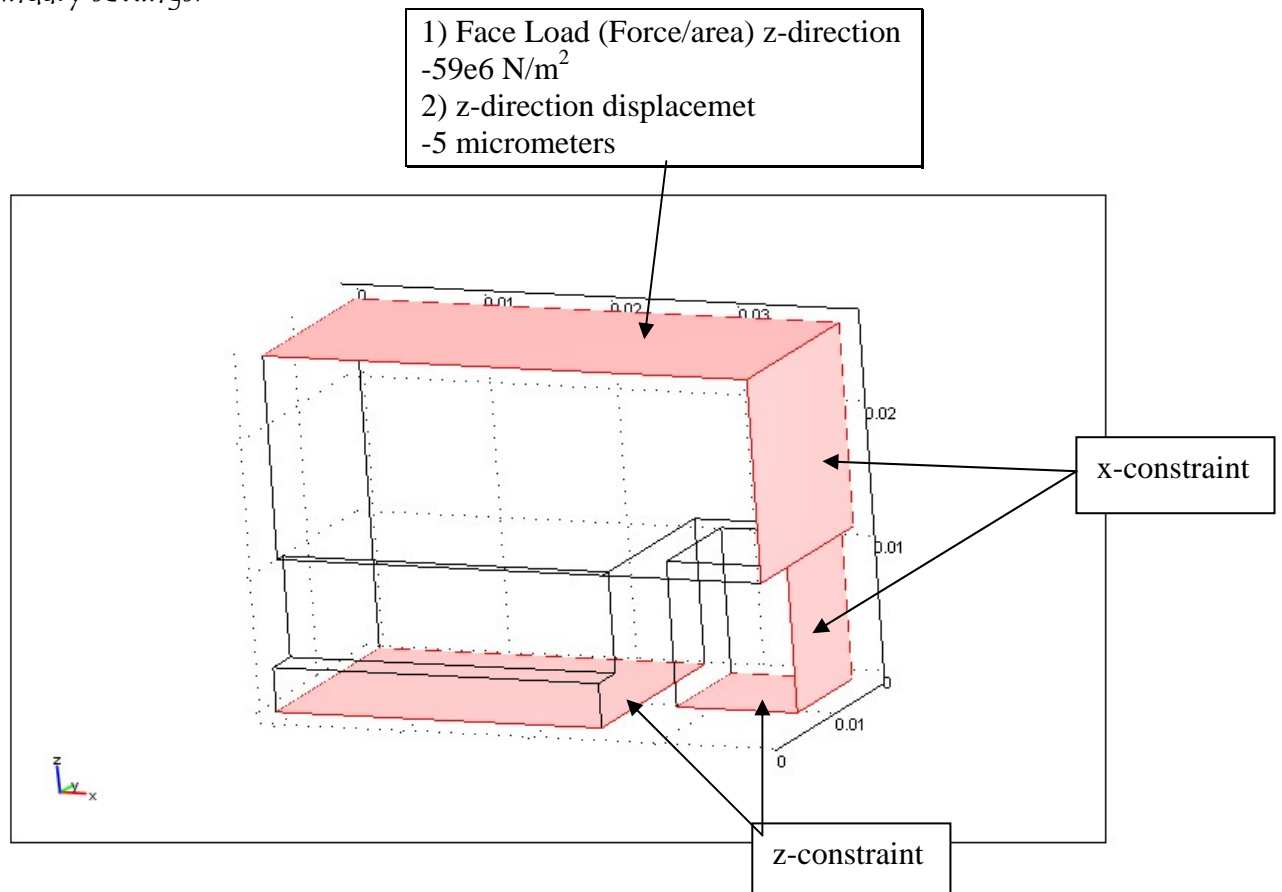
I took real dimensions of the block and I created a model with Femlab....it's not necessary to create the entire structure because it's symmetric, so I worked with a quarter of it (figures below).



Subdomain settings:

MATERIAL PROPERTIES (Steel AISI 4340)	
Young's modulus	205e9
Poisson's ratio	0.28
Density	7850
Mass damping parameter	1
Stiffness damping parameter	0.001

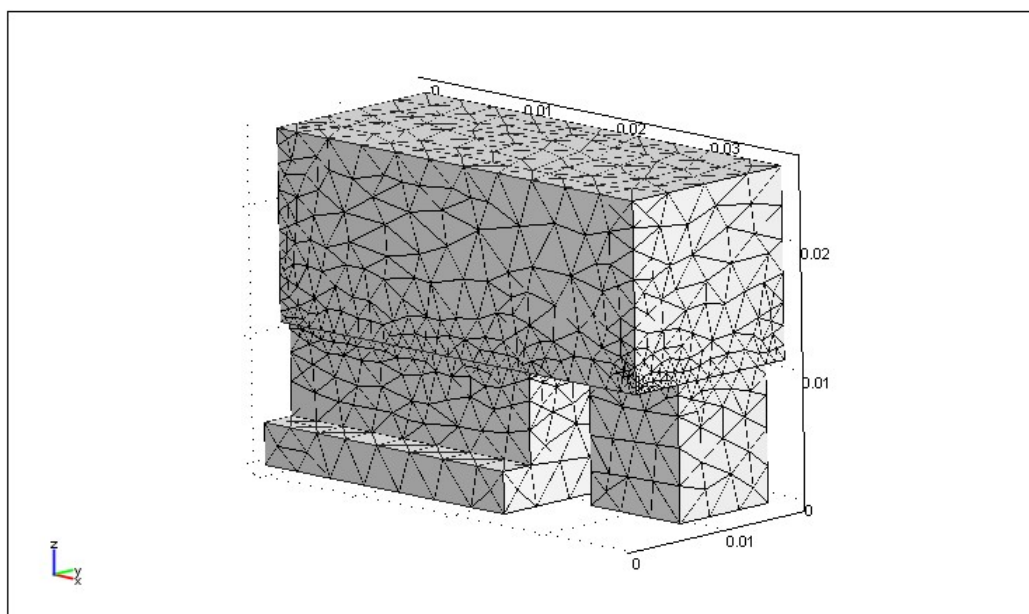
Boundary settings:



$$\text{Strain} = \Delta L / L$$

If strain is about 268 microstrains and L is about 25.9 mm we obtain a value for ΔL of about 6.94 micrometers.

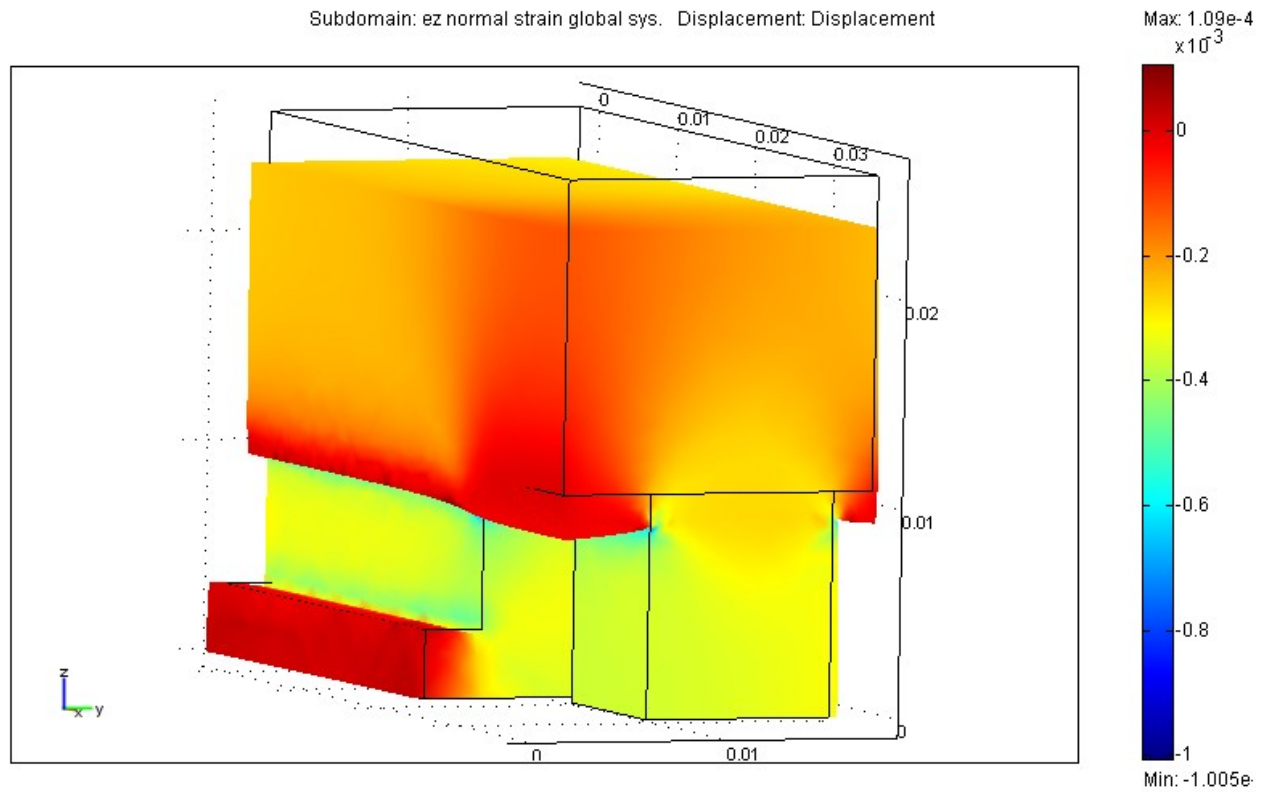
Mesh.....necessary to solve equations' system:



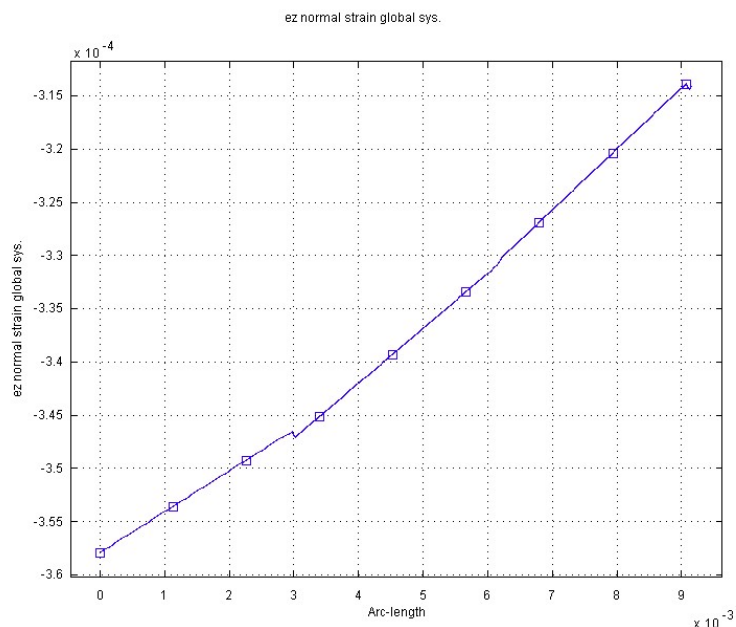
Simulation's results:

- Applying a displacement

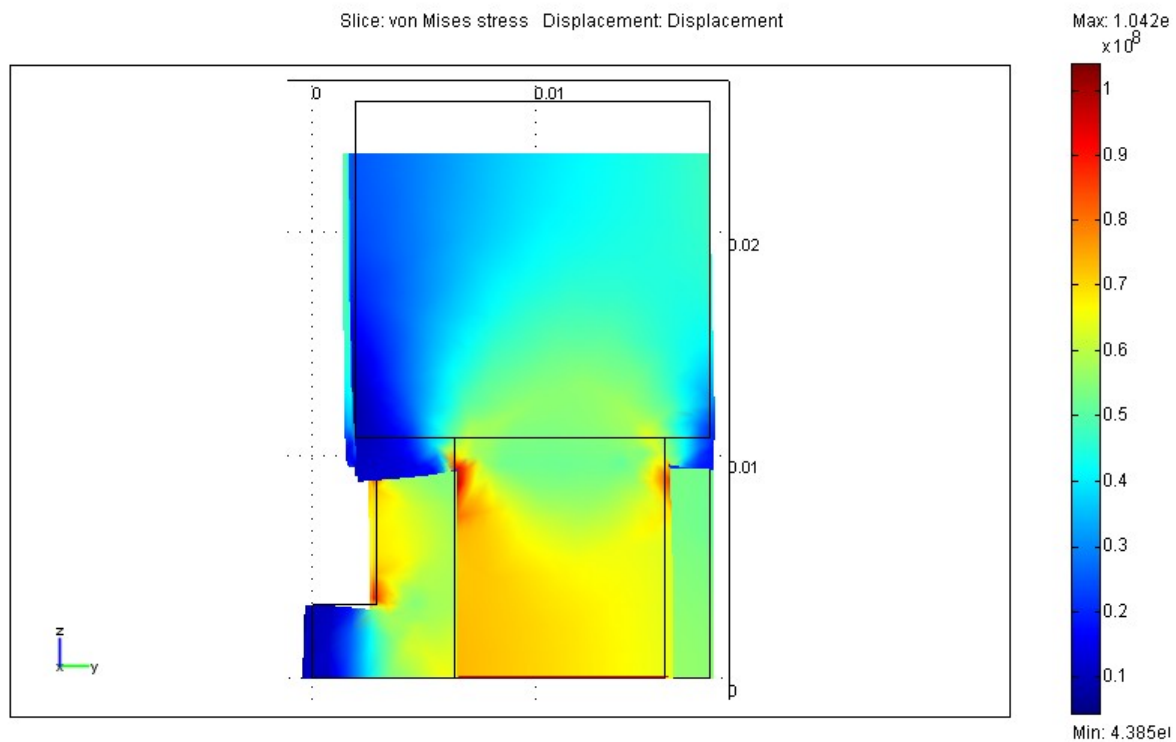
In the figure below is shown z-normal strain distribution



We can calculate strain average plotting it along the width (where sensors should be mounted). We can see that average value is about 335 microstrains that is not so far from calibration one.

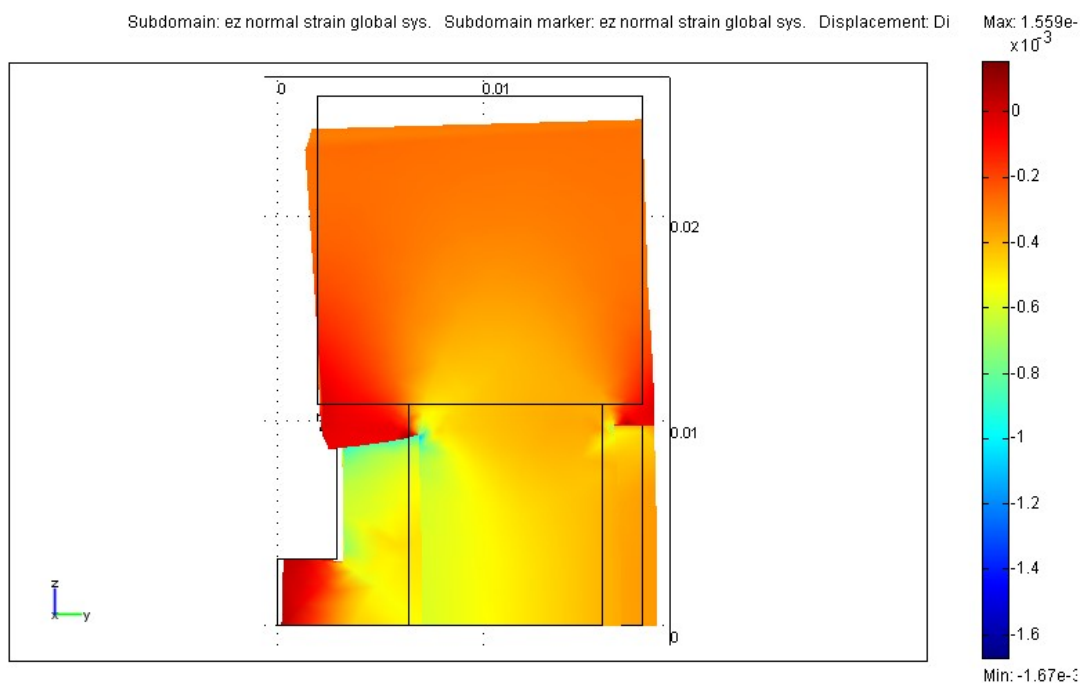


In addition we can observe Von Mises stress distribution:

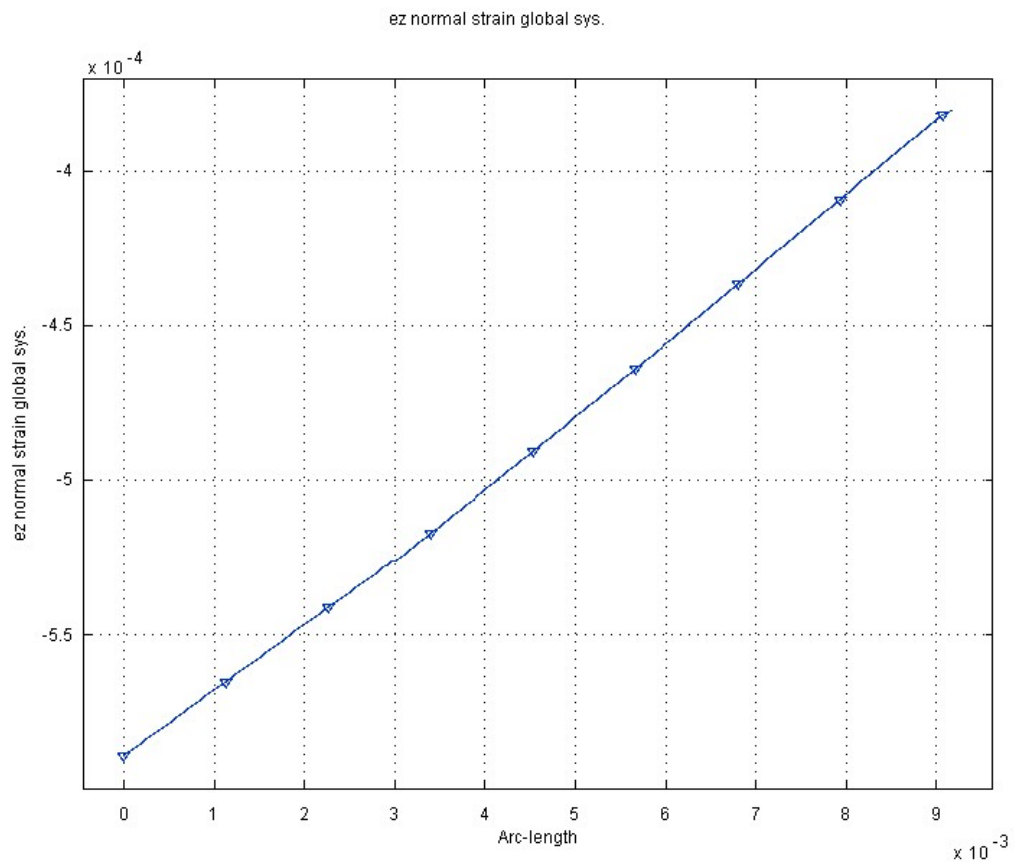


- Applying a face load

I converted value of force from lbs/in² to N/m² and I applied this force to the area at the top....



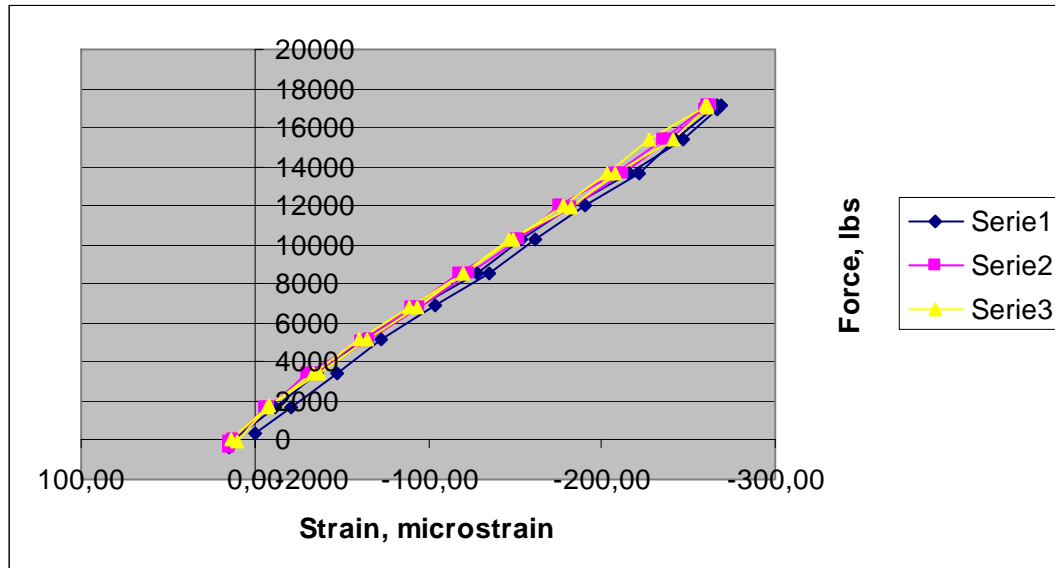
As shown in figure, the top surface has not a parallel motion as we could think. So simulation is not realistic (we can also compare strain plot to make an idea...).



Average value is quite far from the calibration one!!!!!!

Report (part 2)

Cold calibration results:



Max Force applied: 17170 lbs/in²

Max Strain registered: 260 microstrains

Femlab's modeling and simulation

We have to consider 2 elements:

- thermal deformation of steel at 4.2 K
- young's modulus change due to temperature variation

The first effect could be modeled introducing a scale factor in the previous femlab model.

$$\text{Scale factor (SF)} = (L - \Delta L) / L = \alpha * \Delta T$$

Where "alpha" is the thermal expansion coeff. of steel and ΔT is the temperature variation (4.2 K -300 K).

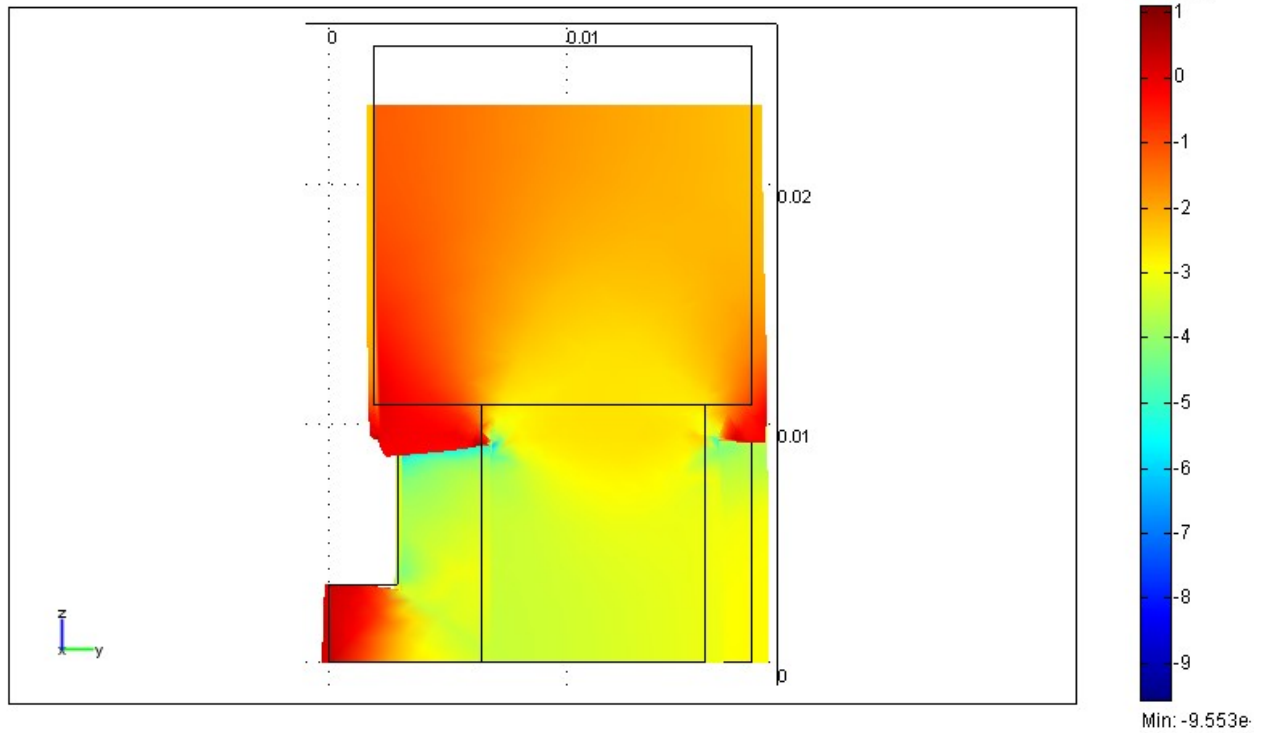
Making calculations we obtains $SF = 0.99636$.

The last effect is empirically modeled by assuming that at this temperature young's modulus increase its value of about 15% ($E_{4.2} = 235.75e9$).

We know that

$$\text{Strain}_{\max} = 260e-6 = \Delta L / L \quad (L = 25.8 \text{ mm}) \text{ so } \Delta L = 6.7 \text{ micrometers (displacement to apply).}$$

Subdomain: ez normal strain global sys. Subdomain marker: ez normal strain global sys. Displacement: Di



ez normal strain global sys.

